Scoliosis

What is Scoliosis?

The Spine

The spine is a column of small bones, or vertebrae, that support the entire upper body. The column is grouped into three sections of vertebrae:

- The cervical (C) vertebrae are the five spinal bones that support the neck.
- The thoracic (T) vertebrae are the twelve spinal bones that connect to the rib cage.
- The lumbar (L) vertebrae are the five lowest and largest bones of the spinal column. Most of the body’s weight and stress falls on the lumbar vertebrae.
- Below the lumbar region is the sacrum, a shield-shaped bony structure that connects with the pelvis at the sacroiliac joints.
- At the end of the sacrum are two to four tiny, partially fused vertebrae known as the coccyx or “tail bone.”

Each vertebra can be designated by using a letter and number; the letter reflects the region (C=cervical, T=thoracic and L=lumbar), and the number signifies its location within that region. For example, C4 is the fourth bone down in the cervical region, and T8 is the eighth thoracic vertebrae.

Vertebrae in the spinal column are separated from each other by small cushions of cartilage known as intervertebral discs. Inside each disc is a jelly-like substance surrounded by a fibrous structure. The disc is 80% water, which makes it very elastic.

Each vertebra in the spine has a number of bony projections, known as processes. The spinal processes and transverse processes attach to the muscles in the back and act like little levers, allowing the spine to twist or bend. The articular processes form the joints between the vertebrae themselves, meeting together and interlocking.

Each vertebra and its processes surround and protect an arch-shaped central opening. These arches, aligned to run down the spine, form the spinal canal, which encloses the spinal cord, the central trunk of nerves that connects the brain with the rest of the body. The upper trunk normally has a gentle outward curve (its kyphosis) while the lower back has a reverse inward curve (its lordosis).

Scoliosis

Scoliosis is a three-dimensional deformity of the spine and rib cage. It may develop as a single primary curve (resembling the letter C) or as two curves (a primary curve along with a compensating secondary curve that forms an S shape). Scoliosis may occur only in the upper back (the thoracic area) or lower back (lumbar), but most commonly develops in the area between the thoracic and lumbar area (thoracolumbar area). The physician attempts to define scoliosis by the shape of the curve, its location, direction and magnitude, and, if possible, its cause. The severity of scoliosis is determined by the extent of the spinal curvature and by the angle of the trunk rotation (ATR).
Defining Scoliosis by the Shape of the Curve. Scoliosis is often categorized by the shape of the curve, either structural or nonstructural.

- In structural scoliosis, the spine not only curves from side to side, but the vertebrae also rotate, twisting the spine. As it twists, one side of the rib cage is pushed outward so that the spaces between the ribs widen and the shoulder blade protrudes (producing the *rib-cage deformity*, or prominence); the other half of the rib cage is twisted inward, compressing the ribs.
- A nonstructural curve does not twist, but is a simple side-to-side curve, and is usually compensatory to the main structural curve.

Other abnormalities of the spine that may occur alone or in combination with scoliosis include *hyperkyphosis* (an abnormal exaggeration in the backward rounding of the spine) and *hyperlordosis* (an exaggerated forward curving of the lower spine, also called swayback).

Defining Scoliosis by Its Location. The location of a structural curve is defined by the location of the *apical vertebra*, the bone at the *apex* (highest point) in the spinal hump. This particular vertebra will also have undergone the most severe rotation.

Defining Scoliosis by Its Direction. Direction of the curve in structural scoliosis is determined by whether the *convex* (rounded) side of the curve bends to the right or left. For example, a physician defines a certain case as right thoracic scoliosis if the apical vertebra is in the thoracic (upper back) region of the spine and the curve bends to the right.

The magnitude of the curve is determined by taking measurements of the length and angle of the curve on an X-ray view.

What Causes Scoliosis?

Possible Causes of Idiopathic Scoliosis

In 80% of patients, the cause of scoliosis is unknown. Such cases are called idiopathic scoliosis, and they account for about 65% of the structural form of scoliosis. Most cases of idiopathic scoliosis have a genetic basis, but researchers still have not identified the gene or genes responsible for them.

Physical Abnormalities. Researchers are investigating possible physical abnormalities that may cause imbalances in bone or muscles that would lead to scoliosis. Among them are the following:

Muscles Around the Vertebrae. Some research suggests that imbalances in the muscles around the vertebrae may make children susceptible to spinal distortions as they grow.

High Arches. One study showed a higher incidence of abnormally high arches in the feet of people with idiopathic scoliosis, suggesting that altered balance may be a factor in certain cases.

Problems in Coordination. Some experts are looking at inherited imbalances in perception or coordination that may cause asymmetrical growth in the spine of some children with scoliosis.

Biologic Factors. A number of biologic factors may contribute scoliosis:

Investigators are looking at possible abnormalities in collagen, the critical structural protein found in muscles and bones. Enzymes known as matrix metalloproteinase are involved in the repair and remodeling of collagen. In high levels, however, the enzymes can cause abnormalities in components in the spinal discs, contributing to disc degeneration. Some researchers have found high levels of the enzymes in the discs of patients with scoliosis, which suggests that the enzymes may contribute to curve progression.

- Other researchers are investigating a possible defective gene responsible for production of fibrillin, an important component of connective tissue, which makes up bones and muscles.
Some research has found higher abnormalities in a protein that binds to calcium, called platelet calmodulin, among patients with scoliosis compared to the general population.

Still other investigators have been studying melatonin, a hormone secreted in the brain that is involved with sleep and growth. Animal studies and some human studies have found abnormalities associated with scoliosis.

**Congenital Scoliosis**

Congenital scoliosis is caused by inborn spinal deformities that usually involve abnormalities in the development of vertebra (absent or fused vertebrae).

The condition usually becomes evident at either age two or between ages 8 and 13 as the spine begins to grow more quickly, putting more stress on the inborn abnormalities. Curvatures in such cases must be monitored closely, since they can progress quickly. (Often kidney problems, particularly having only one kidney, coincide with congenital scoliosis.)

**Scoliosis Caused by Inherited and Medical Disorders**

Scoliosis may also be a result of muscle paralysis or deterioration from diseases such as muscular dystrophy, polio or cerebral palsy. Other diseases that can cause scoliosis are Marfan’s syndrome, Friedreich ataxia, Albers-Schonberg disease, rheumatoid arthritis, and osteogenesis imperfecta. Injury to the spinal cord may also cause scoliosis. A very rare genetic disease called familial dysautonomia has been identified as a cause of scoliosis in Jewish children of Ashkenazi descent. (It should be noted that only 500 cases have been reported.) Birth defects known to cause scoliosis include spinal bifida or myelomeningocele (a hernia of the central nervous system).

**Spinal Tumors or Abnormalities**

Tumors, growths or small abnormalities on the spinal column may play a larger role than previously thought in the causes of scoliosis in small children. Back surgery for removal of benign tumors increases the risk for spinal deformity.

**Causes of Nonstructural Scoliosis**

Nonstructural scoliosis is sometimes caused by poor posture, differences in leg length and muscle spasms.

**Who Gets Scoliosis?**

**Risk Factors for Scoliosis**

*General Risk Factors of Idiopathic Scoliosis.* Idiopathic scoliosis (in which the cause is unknown) is the most common form. It nearly always occurs during the growth spurt right before and during adolescence. It can also occur, however, in young children and even in infants. About 2% to 3% of adolescents develop curvature of 10 degrees or more, but only about 0.3% to 0.5% have curves greater than 20 degrees. Mild curvature occurs about equally in girls and boys, but curve progression is 10 times more likely to occur in girls.

*Medical Risk Factors.* People with certain medical conditions that affect the joints and muscles are at higher risk for scoliosis. [See Scoliosis Caused by Medical Disorders, above.] About 10% of girls with Turner’s syndrome, a common genetic disease in women, develop scoliosis.

*Young Athletes.* A 2000 study reported that young girls engaged in rhythmic gymnastics had a 10-fold increased risk for scoliosis. This higher risk is possibly due to three coinciding factors: an imbalance in the weight on the spine, a loosening of the joints and a delay in the onset of puberty. (Delayed menstruation is a common risk factor in all young, competitive female athletes as are stress fractures and possibly scoliosis.)
Risk Factors for Progression in Children and Adolescents with Scoliosis

Once a mild curve has been observed, the next step is more difficult, predicting whether the curve will progress into a more serious condition. Although as many as three in every 100 teenagers have a condition serious enough to need at least observation, the potential for severity may be significantly lower or higher than average depending on other factors.

- Being female or at a younger age at the onset of scoliosis increases the risk.
- The greater the angle of the curvature, the greater the risk. At 20 degrees, only about 20% of curves progress. Young people diagnosed with a 30-degree curve, however, have a risk for progression of 60%; with a curve of 50 degrees, the risk is 90%.
- Curvatures may be less likely to progress in girls whose scoliosis was low in the back and whose spine was out of balance by more than an inch.
- Taller girls appear to be at higher risk.
- Curvatures from congenital scoliosis (spinal problems present at birth) may progress rapidly.

This would mean, for example, that a shorter-than-average girl of 14 with low-back scoliosis of 25 to 35 degrees, but whose spine is imbalanced by over an inch would have almost no risk. The same degree of curvature in the chest region of a tall 10-year-old girl whose spine was in balance, however, would almost certainly progress. Children with scoliosis who are treated with growth hormone appear to be at high risk for progression, which is frequently rapid.

Risk Factors for Progression in Adult-Onset Scoliosis

In rare cases, scoliosis may develop in adults who may have had unrecognized or untreated scoliosis in their youth. Osteoporosis, which is a serious problem in many older adults, can cause even mild curvatures to progress. (Osteoporosis itself is not a risk factor for new-onset scoliosis.) In most cases, however, it is not known why adult’s curves progress.

How Serious is Scoliosis?

Effect on Lungs and Heart

In general, the severity of the scoliosis depends on the degree of the curvature and whether it threatens vital organs, specifically the lungs and heart. (It should be noted, however, that in general, the morality rate for patients who had adolescent idiopathic scoliosis is normal.)

Effect of Mild Scoliosis (less than 20 degrees). Mild scoliosis is not serious and requires no treatment other than monitoring.

Effect of Moderate Scoliosis (Between 25 and 70 degrees). It is still not clear whether moderate scoliosis causes significant health problems. In one study, adults with moderate scoliosis had normal lung function, although they had difficulty exercising. (The researchers believed that this low exercise tolerance might have been because many patients with scoliosis do not engage in regular physical activity.)

Effect of Severe Scoliosis (Over 70 degrees). If the curvature exceeds 70 degrees, the severe twisting of the spine that occurs in structural scoliosis can cause the ribs to press against the lungs, restrict breathing and reduce oxygen levels. One study concluded that almost two-thirds of patients with curves of 90 degrees and under had less than 80% of normal lung capacity. The distortions can also affect the heart and cause dangerous changes.

Effect of Very Severe Scoliosis (Over 100 degrees). Eventually, if the curve reaches over 100 degrees, both the lungs and heart can be injured. Patients with this degree of severity are susceptible to lung infections and pneumonia. Curves greater than 100 degrees increase mortality rate, but this problem is very uncommon in America.
Osteopenia and Osteoporosis

Osteopenia is the general term for the loss of bone density in everyone. Osteoporosis also means loss of bone density, but it is related to aging. A number of factors associated with scoliosis increase the risk for bone loss and put patients at higher risk for osteoporosis later on. Osteoporosis is a common problem in older women, and is particularly dangerous for women with a history of scoliosis. Experts recommend that children with scoliosis be screened for osteopenia, so measures can be taken to help prevent osteoporosis later on. Women with existing osteoporosis should take all precaution, including exercise, calcium and vitamin D supplements, and possibly hormone replacement therapy or other bone-density building treatments.

Back Problems in Adulthood Related to Scoliosis

Low Back Pain. Studies report that patients with scoliosis have the same incidence of back pain as the general population, which is very high (60% to 80%). In one study conducted 20 years after growth had stopped, two-thirds of adults who had lived with curvatures of 20 to 55 degrees reported they experienced back pain. In this study, most cases were mild, although others have reported that adults with a history of scoliosis tend to have chronic and more back pain than the general population.

Pain in adult-onset or untreated childhood scoliosis often develops because of posture problems that cause uneven stresses on the back, hips, shoulders, neck and legs. Patients who were surgically treated with fusion techniques lose flexibility and may experience weakness in back muscles due to injuries during surgery. Those who had eight or more fused vertebrae are at higher-than-average risk for disk degeneration in their 30s and 40s.

Spondylosis. Nearly all individuals with untreated scoliosis at some point develop spondylosis, an arthritic condition in the spine. The joints become inflamed, the cartilage that cushions the disks may thin, and bone spurs may develop. If the disk degenerates or the curvature progresses to the point that the spinal vertebrae begin pressing on the nerves, pain can be very severe and may require surgery. Even surgically treated patients are at risk for spondylosis if inflammation occurs in vertebrae around the fusion site.

Lower Back Problems Related to Early Surgeries. Not only the disease itself, but surgical treatments in childhood, increase the risk for back problems in adulthood. [See What Are the Surgical Treatments for Scoliosis?, below.]

Long-Term Emotional Impact of Scoliosis and its Treatments

Emotional Impact in Childhood. The emotional impact of scoliosis, particularly on young girls or boys during their most vulnerable years, should not be underestimated. Adults who have had scoliosis and its treatments often recall significant social isolation and physical pain. Follow-up studies of children who had scoliosis without having strong family and professional support often reported significant behavioral problems. Fortunately, current treatments are solving many of the problems that previous generations had to deal with, including unsightly bracing and extremely painful surgeries with little pain control.

Emotional Effects in Adults. Adults with a history of scoliosis, even those whose conditions were corrected, should understand that the effects of scoliosis can last a lifetime. Many studies have found that women who had both surgery and bracing have a lower body image in adulthood than those who had only worn braces. A Scandinavian study reported that adults with scoliosis had less job opportunities and a lower marriage rate than the general population. (The group studied, however, included patients with severe medical problems, such as tuberculosis or polio, and such results may not apply to those with idiopathic adolescent scoliosis.)

Effects on Pregnancies

A history of scoliosis appears to have little or no effect on complications during pregnancy or outcome for the child, nor does pregnancy have any serious adverse effects on scoliosis, although back pain may occur.
**Risks from X-Rays**

Although the risk for developing cancer or reproductive defects from X-rays is very small, particularly with new protective measures, a 2000 study reported that certain patients treated for scoliosis between 1980 and 1993 had some risk. The risks were highest in those who had the largest radiation exposure. Patients who had been surgically treated, then, had the greatest risks, which were 0.8% for leukemia, 2.1% for breast cancer, and 3.0% for a hereditary defect. Those who simply received X-ray series for idiopathic scoliosis or scoliosis caused by uneven length of legs or hip abnormalities had a very low risk (less than 1%).

**What are the Symptoms of Scoliosis?**

Scoliosis is usually painless. Often the curvature itself may be too subtle to be noticed by even observant parents. Some may notice abnormal posture in their growing child that includes a tilted head, protruding shoulder blade and one hip or shoulder that is higher than the other, causing an uneven hem or shirt line. The child may lean more to one side than another.

With more advanced scoliosis, fatigue may occur after prolonged sitting or standing. Curves caused by muscle spasms or growths on the spine can sometimes cause pain.

Nearly always, however, there are no symptoms for mild scoliosis, and the condition is usually detected by the pediatrician or during a school screening test. [See How is Scoliosis Diagnosed?, below]

**How is Scoliosis Diagnosed?**

The severity of scoliosis and need for treatment is determined by the extent of the spinal curvature, and by the angle of the trunk rotation (ATR). Both are measured in degrees. The two factors are usually related, so that, for example, a person with a spinal curve of 20 degrees usually has a trunk rotation (ATR) of 5 degrees. Such a measurement used to be the criteria for recommending treatment, although it is now known that up to 80% of 20-degree curves do not get worse. Scoliosis is diagnosed when the curve measures 11 degrees or more, but treatment is not usually required until the curve reaches 30 degrees and the ATR is 7 degrees.

**Physical Examination**

*Forward Bend Test.* The screening test most often used in schools and in the offices of pediatricians or primary care physicians is called the forward bend test, in which the child bends forward dangling the arms, with the feet together and knees straight. The curve of structural scoliosis is more apparent when bending over, and the examiner may observe an imbalanced rib cage, with one side being higher than the other or other deformities. The forward bend test is not sensitive to abnormalities that occur in the lower back, which is a very common site for scoliosis. It, therefore, misses about 15% of scoliosis cases, and many experts do not recommend this test as the sole method for screening for scoliosis.

*Other Physical Tests.* The patient is usually requested to walk on the toes, then the heels, and then is asked to jump up and down on one foot. Such activities indicate leg strength and balance. The physician will also check for tight tendons in the back of the leg, which is usual in adolescence, but may also indicate nerve root irritation or spondylolysis, a condition in which one vertebra has slipped forward over the other. The physician will also check for neurologic impairment by testing reflexes, nerve sensation and muscle function.

**Identifying the Curvature**

Proper diagnosis is important, since a misjudgment can lead to unnecessary X-rays and stressful treatments in children not actually at risk for progression. Unfortunately, although measurements of curves and rotation are useful, no test exists yet to determine whether a curve will progress.
Inclinometer (Scoliometer). An inclinometer (Scoliometer) measures distortions of the torso. The procedure is as follows:

The patient is asked to bend over with arms dangling and palms pressed together, until a curve can be observed in the thoracic area (the upper back). The Scoliometer is placed on the back and used to measure the apex (the highest point) of the curve. The results of the Scoliometer can indicate problems, and some experts believe it would make a useful device for widespread screening. Scoliometers, however, measure rib cage distortions in more than half of children who turn out to have very minor or no sideways curves. Scoliometers are not accurate enough to guide treatment, and if results show a deformity, X-rays need to be performed.

Imaging Tests

Currently X-rays are the most cost-efficient method for diagnosing scoliosis. Experts hope that an accurate, noninvasive diagnostic technique can be developed that may eventually replace some of the X-rays currently used to monitor the progression of scoliosis. To date, some of these techniques appear to be fairly accurate for detecting scoliosis in the upper back (the thoracic region) but not scoliosis in the lower back (the lumbar region).

X-Rays. If screening indicates scoliosis, the child may be sent to a specialist who takes an initial X-ray and monitors the child every few months using repeated X-rays. X-rays are essential for an accurate diagnosis of scoliosis in many ways:

- X-rays reveal the degree and severity of scoliosis.
- X-rays identify any other spinal abnormalities, including kyphosis (hunchback) and hyperlordosis (swayback).
- X-rays also help the physician determine whether or not skeletal growth has reached maturity.
- X-rays of bending patients can help differentiate between structural and nonstructural scoliosis.

Structural curves persist when a person bends over, and nonstructural curves tend to disappear. (It should be noted that muscle spasms or spinal growths may sometimes cause nonstructural scoliosis that shows a curve on bending.)

In children and young adolescents who have mild curves or in older adolescents who have more severe curvatures, but whose growth has stopped or slowed down, X-rays should be performed every few months in order to detect increasing severity. Young people who are diagnosed with scoliosis should be sure to keep their X-rays indefinitely in case they develop back problems later in adulthood and need to be re-examined.

Protective Measures for Frequent X-Rays

Because frequent X-rays may be required on young children, parents should see that X-ray technicians take all necessary protective methods. Experts are concerned about the long-term effects of radiation on sensitive young organs, particularly about a possible increase in the risk for cancer. Studies have reported an increased risk for cancer in women and men who, because of scoliosis, had been exposed to diagnostic X-rays in their childhood and adolescence.

X-ray techniques have become safer in recent years, and the hazards may be reduced with simple measures:

- X-ray beams should be directed through the patient from back to front, rather than the reverse.
- Filters for the X-ray tube are available that absorb some of the beam.
- Fast film should be used, which can reduce exposure by two to six times.
- Lead aprons or shields should always be worn over parts of the body that are not being X-rayed.
**Magnetic Resonance Imaging.** Magnetic resonance imaging (MRI) is an advanced imaging procedure that does not use radiation, as X-rays do, but it is expensive and many experts believe it is not needed for diagnosing scoliosis. MRI, however, can identify spinal cord and brain stem abnormalities, which some studies indicate may be more prevalent than average in children with idiopathic scoliosis. It also may be particularly useful before surgery for detecting potential complications.

**Calculating the Curve**

*Cobb Method.* The degree of the curve is nearly always calculated using a technique known as the Cobb method.

On an X-ray of the spine, the examiner draws two lines: One line extends out and up from the edge of the top vertebrae of the curve. The second line extends out and down from the bottom vertebrae. A perpendicular line is then drawn between the two lines. The intersecting angle is measured to determine the degree of curvature.

The Cobb method is limited because it cannot fully determine the three-dimensional aspect of the spine. It is not as effective, then, in defining spinal rotation or kyphosis. It also tends to over-estimate the curve. Other diagnostic tools are needed to make a more accurate diagnosis.

A new technique using calculations based on geometric principles of the apex of the curve as well as the top and bottom of the curve may prove to be accurate in determining all the dimensions of the curve.

**Determining the End of Growth**

Even if the curve is accurately calculated, it still remains difficult to predict whether the scoliosis will progress. One way of predicting whether or not the curvature will progress is knowing when the child will stop growing. If the child has years to grow, then the spine has more time to progress. If the child will stop growing within a year, then progression should be very slight. (It should be noted, however, that some progression occurs in nearly 70% of curves even after the spine has matured.)

Knowing the child’s age is, of course, the first step in estimating the end of growth. In addition, other methods have been developed to help predict the end of the growth stage.

One method is called the Risser sign, which grades the amount of bone in the area at the top of the hip bone. A low grade indicates that the skeleton still has considerable growth; a high grade means that the child has nearly stopped growing and a small curve is unlikely to progress much further. The Risser scale differs between genders and in boys.

**To Screen or Not to Screen for Scoliosis**

Screening programs for scoliosis, which began in the 1940s, are now mandatory in middle or high schools in many states. The American Academy of Orthopaedic Surgeons recommends that girls be screened twice, at ages 10 and 12, and that boys be screened once at 13 or 14. One study, however, argues that over 40% of high school sophomores with newly diagnosed scoliosis had shown no signs of the disorder in earlier screening tests. The American Academy of Pediatrics recommends scoliosis screening at ages 10, 12, 14 and 16 years.

*Arguments Against Screening.* In 1993, the U.S. Preventive Services Task Force issued a recommendation against routine screening to detect adolescent scoliosis. Experts on the task force argued the following:

- Screening tests are not accurate and depend too much on the skill of the examiner.
- Schools often refer children with minor curves who are not at any risk for a progressive or serious condition to physicians, and such over-referrals add considerably to the costs of the health system. In one major 1999 study, 94% of the children referred to a physician by the school did not require treatment. (Over 2,000 children were screened in order to find only five children who did need treatment.)
- At the time of the Task Force, studies were also showing no benefits from the early treatments, specifically braces.
Experts against screening argue, then, that such programs result in early treatments that either will not prevent curve progression and surgery, or are unnecessary in the first place since curvatures often do not progress at all.

**Arguments for Screening.** Other experts make the following arguments for universal screening:

- Universal screening is useful for producing information on scoliosis that may eventually lead to knowledge of its cause and ways to prevent it.
- Braces have been proven to be effective since the Task Force’s recommendation, and early treatment can be important.
- Without screening, the chances are slim that children with scoliosis will be diagnosed at an early stage if they can only rely on examinations by a family physician or pediatrician. Such physicians often do not even look at backs and, if they do, they tend to use only the forward bend test, which is not accurate.
- Finally, wide-spread screening would be cost effective if schools had reasonable guidelines, such as the following, to use for determining which children should see a physician for further testing:

  Children should be sent to a physician only if they have a 30-degree curve. (A 20-degree curve with a 5-degree trunk rotation has been the criteria for recommending treatment, although up to 80% of 20-degree curves do not get worse.)

  Children with curves between 20 and 30 degrees would be screened every six months.

  Such guidelines would detect about 95% of all genuinely serious cases while referring only 3% of all children tested, thereby cutting costs without jeopardizing children.

**What are the General Guidelines for Scoliosis?**

Treatment for scoliosis has undergone major changes over the past decade and a number of options are available.

**Decision to Treat**

The general rule of thumb for treating scoliosis is to monitor the condition if the curve is less than 20 degrees and to consider treating curves greater than 25 degrees or those that progress by 10 degrees while being monitored. Whether scoliosis is treated immediately or simply monitored is not an easy decision, however. The percentage of cases that will progress more than 5 degrees can be as low as 5% in certain cases and as high as 50% to 90% depending on severe curves or other predisposing factors:

- **Age.** In general, the older the child, the less likely the curve will progress. Experts estimate that curves less than 19 degrees will progress 10% in girls between ages 13 and 15 years and 4% in children older than 15 years. (In some rare, severe cases, a curve may worsen even after treatment and end of growth because of the weight of the body pressing against the abnormal curve.

- **Gender.** Girls have a higher risk for progression than boys.

- **Location of the Curvature.** Thoracic curves, those in the upper spine, are more likely to progress than thoracolumbar curves or lumbar curves, those of the middle to lower spine.

- **Severity of the Curvature.** The higher the degree, the more likely the lungs will be affected.

- **Presence of Other Health Conditions.** Children in poor health may suffer more from stressful scoliosis treatments than other children. On the other hand, children who have existing conditions that threaten the lung and heart problems may warrant immediate, aggressive treatment.
For example, a young man of 18 who has a curvature of 30 degrees may require no treatment because his growth has probably almost stopped and his gender puts him at lower risk. A young girl of 10, however, with the same curvature requires immediate treatment.

Braces or Surgery

Although braces are recommended for moderate curves, and surgery for more severe ones, the choice may not be so straightforward in certain cases. Braces tend to be used in children with curvatures between 25 and 40 degrees who still will be growing significantly. Surgery is suggested for patients with curvatures over 50 degrees, in untreated patients or when braces have failed. In adults, scoliosis rarely progresses beyond 40 degrees, but surgery may be required if the patient is in a great deal of pain or if it is causing neurologic problems.

Estimating The Extent of Curvature Progression

In Children and Adolescents:

- In a study of patients whose curves did progress after diagnosis, 34% progressed more than 10 degrees, 18% progressed more than 20 degrees, and 8% progressed more than 30 degrees.

In Adult-Onset Scoliosis:

- Curvatures under 30 degrees almost never progress.
- Predicting progression at curves around 40 degrees is not clear.
- Curvatures over 50 degrees are at great risk for progression.

What are Measures for Managing the Effects of Scoliosis?

Exercise

For anyone, exercise has many health benefits and is important for maintaining strength and muscle tone and stabilizing weight.

Exercise for Prevention of Progression. Early studies did not find any reduction in curves or slowing of progression with exercise. Few were performed, however, and German researchers have suggested that such studies were done before specific exercises were developed that might be helpful. In their study, patients with an average curvature of 27% showed less progression after physiotherapy than that expected in patients with no treatment.

A small 2000 U.S. study used a MedX Torso Rotation machine that trains and strengthens the muscles that turn the torso. In the study, the patients increased strength from 12% to 40%. One girl with a severe lumbar curve required surgery, but no curvature in the remaining 11 patients progressed, and four of the patients experienced a reduction in their curvature. No braces were used. Exercising the torso to build muscle strength is important, in any case, in conjunction with braces. [See What Are the Braces Used for Scoliosis?, below]

Stretching exercises may be beneficial in children whose scoliosis is due to uneven leg lengths or a shortened tendon.

Airway Ventilation at Night

Some studies have investigated the use of airways systems, such as nasal continuous positive airflow pressure, for patients with severe scoliosis and reduced lung capacity. Such systems are used during the night to force air into the upper airways and into the lungs. In one study, the use of these devices reduced hospitalization and improved lung function, shortness of breath and fatigue. Such systems are used in the treatment of sleep apnea, a common sleep disorder.
Heel Lifts for Secondary Scoliosis

When secondary scoliosis is caused by differences in leg lengths, adding lifts to the heels may decrease a mild curvature. In one study it decreased by an average of 5.3 to 7.5 degrees. (Curvatures were all under 20 degrees.) Patients with the greatest curvature experienced some muscle pain, fatigue and even nausea during the first few days they were using the lifts, but these symptoms lessened within 10 days.

What are the Braces Used and Nonsurgical Treatments for Scoliosis?

Braces

For moderate curves of 24 to 40 degrees, a brace is often used to prevent further curvature. It is important to note that a brace will almost never reverse an existing curve, and is only used to stop its progression. (Rare instances of correction have been reported, and the brace may be helpful in correcting a side-to-side curve, but it has little effect on rotation.)

Many experts have questioned, in fact, whether a brace is any better than nature in halting the progress of a curve. Early studies found braces successful in only half the cases. A major 1997 analysis of studies, however, reported no significant curve progression for the following patients:

- 92% of those who wore any braces, with the best success rates (99%) being from the Milwaukee brace.
- 93% of patients who wore braces for 23 hours a day.
- 60% who wore them for eight or 16 hours a day.
- Half of patients who had no treatment.
- 40% of patients receiving electrical stimulation.

Braces Types

Milwaukee Brace. A full torso brace called the Milwaukee brace was standard treatment until a decade ago and is still used. The device uses a wide flat bar in front and two smaller ones in back that attach to a ring around the neck that has rests for the chin and back of the head. One study determined that lying on the chest when the brace is worn is the best position for correcting the curve. Some researchers then suggested that increasing the tension on the chest straps might add benefit. The brace is periodically adjusted for growth. The brace needs to be worn 23 hours a day with relief only during bathing and exercise. Compliance is a major problem. In one study, only 15% of patients wore the Milwaukee brace as directed. This brace is particularly difficult to endure. One woman who had worn it for seven years during adolescence remembered herself as being invisible at school, ignored and shunned by other children.

The Wilmington, Boston and TLSO Braces. Newer, molded braces called thoracolumbar-sacral orthoses (TLSOs or the Wilmington brace) come up to beneath the underarms and can be fitted to be worn close to the skin so that they don’t show under clothes. Patients are still urged to wear these braces 20 hours a day; although wearing them for 16 hours a day may still be beneficial, the risk for curve progression is significantly higher when patients wear braces for less time. Young people often refuse to wear even the newer braces, and emotional support from the family and professionals is extremely important to help a child accept the process and sustain compliance. Even these braces can cause difficulties; they are hot, reduce lung capacity by nearly 20%, and cause mild, temporary changes in kidney function.

The Charleston Bending Brace. The Charleston Bending Brace is worn only at night, and some physicians question its value due to the paucity of studies with this brace. In one study, 66% of patients improved, and 17% progressed to the point where they needed surgery.

SpineCor. A new bracing method (SpineCor) uses adjustable bands and a cotton vest that allows flexibility. The long-term effectiveness of this brace is not yet known, since there are no studies on this brace.
Quality of Life. In one 1999 study, brace treatment did not negatively affect the self-images of the adolescents who had to wear them. Another study, however, suggested that the type of brace does affect quality of life, with patients who had the Milwaukee brace reporting the greater impairment than patients with the Wilmington, Boston, TSLO or Charleston braces. The choice of brace should be one that will be the most effective for a particular patient with the lowest impact on quality of life.

Exercise and Physical Therapy while Wearing Braces. For children who require braces, an exercise program helps their sense of well-being, improves compliance with treatment, and keeps muscles in tone so that the transition period after the brace is removed is easier. Exercise is important for chest mobility and proper breathing, to maintain muscle strength, especially in the abdominal muscles, and to maintain flexibility in the spine.

One small study showed that patients who performed exercises that improved flexibility in the torso experienced less spinal twisting and had improved curvature. Another reported that young girls who wore the Boston brace and performed aerobic exercises for 30 minutes four times a week experienced improved lung function, where as it declined in girls who did not exercise.

Practicing correct posture, especially in front of a mirror, is an extremely important part of the physical therapy program. A patient who is accustomed to a curved spine may have the sensation of being crooked when first taught to properly align the spine; practicing in front of a mirror provides a reality check.

Patients tend to comply with the exercise program in the period when the brace is first being used, stop exercising when they have gotten used to the brace, and resume exercising around the time the brace is being removed. If they have not continued this program, their backs will feel weak at the time of removal.

Improving Compliance. Compliance is difficult and appears to be essential for success. A team approach, with several health professionals involved, is usually beneficial and often necessary to support the patient through the bracing process. An orthopedic surgeon interprets the X-rays, assesses the potential progression of the scoliosis, and plans the treatment with the patient and family. If a brace is used, an orthotist measures and fits the patient with the device. A physical therapist plans the exercise program best suited for the patient. Patients must also be taught to conduct daily activities while wearing the brace. A nurse may also be involved to coordinate the treatment plans and provide physical and emotional support.

Other Techniques

Electrostimulation. Electrostimulation has been used in some cases of mild scoliosis, but most studies have now reported that it does no better than observation in stopping progression.

Biofeedback. Biofeedback has been investigated on the premise that being given a signal to improve one's posture when slumping may reduce spinal deformities in some cases. (Some experts believe that braces work only because the young patients self-correct their curves by retraining their posture to avoid the discomfort of the brace.)

What are the Surgical Treatments for Scoliosis?

General Guidelines

The goals of scoliosis surgery are to straighten the spine as much and as safely as possible, to balance the torso and pelvic areas, and to maintain correction. These goals are accomplished by fusing (joining together) the vertebrae along the curve and supporting these fused bones with instrumentation (rod, screws, hooks and other devices) attached to the spine. Many variations exist. All of the operations require meticulous skill. A number of variations on scoliosis surgery exist, using different instruments and procedures. Advanced three-dimensional imaging techniques are allowing the design of instrumentation and minimally invasive techniques that are able to address the problem of the curvature in a comprehensive way with less severe after effects. In most cases of any scoliosis surgeries, however, success depends less on the type of operation than on the skill and experience of the surgeon. Parents of patients or adult patients should not be shy in asking the surgeon and hospital about their experience with specific procedures being considered. It is well proven that in other surgeries (cardiac bypass and joint replacement), surgeons and hospitals with the most experience have the lowest complication rates and their patients have a shorter length of stay in the hospital.
Surgical Candidates

Surgery is almost always recommended for adolescents whose curve exceeds 45-50 degrees and for growing children whose curve has gone beyond 40 degrees. For children whose scoliosis is due to inborn abnormalities, the younger they are when surgery is performed, the better their chances for success. It should also be performed as early as possible for children with multiple physical handicaps; older children who have surgery tend to experience improved well-being from the changes in their appearance, even if they have no actual improved physical functioning.

In adults with scoliosis, surgery is almost never recommended for curvatures under 30 and almost always recommended for adults with curvatures over 60 degrees; those over 100 are life-threatening. Surgeons prefer not to surgically treat curves between 30 and 60 degrees unless they appear to be progressing or are causing pain. (Progression in adults is not common and the cause is usually not known.) Even if such adult patients are experiencing severe back pain related to scoliosis, the choices are still not simple. Surgery relieves pain significantly in 65% to 75% of adult patients. Surgeons prefer to operate on adults under 50 years old, although surgery may be appropriate in some older people. Adult spines are less flexible than children’s are. Usually, however, the correction still achieves an acceptable cosmetic improvement. Experts hope that new surgical advances being used for children will be beneficial for adults as well.

Preoperative Care

Before the operation, a complete physical examination is conducted to determine leg lengths, muscle strength, lung function, and any postural abnormalities. The patient is trained in deep breathing and effective coughing to avoid lung congestion after the operation. The patient should also be trained in turning over in bed in a single movement (called log-rolling) before the operation. Patients are encouraged to donate their own blood before the operation for use in possible transfusions. The patient should have no sunburn, rashes, or sores on the back before the operation, which will increase the risk for infection.

Fusion

The Fusion Procedure. All scoliosis operations involve fusing the vertebrae, but the instruments and devices used to support the fusion vary: [See Instrumentation, below]

Fusion is done by first creating flaps to expose the backs of the vertebrae that make up the curve. The surgeon then removes the facets, the bony joints along the vertebrae that allow the spine to twist and bend. The surgeon lays bone graft across the exposed surface of each vertebra, being careful that they touch the adjoining vertebrae. The flaps are then folded back to their original position, covering the bone grafts. These grafts will regenerate and fuse the vertebrae together.

The Grafts: Bone grafts are usually autografts; that is, they are taken from the patient’s hip, spine or other bones. Many surgeons are also using allografts, which are bone grafts taken from the bone bank. Because autografts are taken from the patient, the operation is longer and the patient may experience more pain afterward than if allografts are used. Allografts, however, pose a theoretical risk for infection from the donor, but the way in which they are prepared seems to minimize this risk. All grafts are tested for bacterial and viral contamination.

Investigators have been testing a bone graft substitute material made of tricalcium phosphate for grafts. When mixed with the patients own bone marrow, these materials make a powerful scaffold for the patients own bone to grow in and around, and slowly replace. Correction loss was also better with the synthetic materials. The large advantage of these materials is that they eliminate any risk for viral infection.

Healing. The healed fusions harden in a position to prevent further curvature, leaving the rest of the spine flexible. It takes about three months for the vertebrae to fuse substantially, although one to two years are required before fusion is mature and complete. At that point, the rods are not really necessary, but are almost always left in place unless infection or other complications occur. Fusion stops growth in the part of the spine that is fused, but most growth occurs in the long bones of the body, so the patient will most likely gain height from the straightened spine and growth in the legs.
Instrumentation

The purpose of instrumentation is to internally immobilize the spine until the fusion heals biologically. The instrumentation allows us to correct the curve, but the purpose is to achieve spinal balance, not correct the curve completely.

Harrington Procedure. Until 15 to 20 years ago, the standard instruments used in fusion procedures were those of the Harrington procedure, first developed in the 1960s. To support the fusion of the vertebrae, the surgeon used a steel rod, extending from the bottom to the top of the curve.

The rod is attached by hooks that are suspended from pegs inserted into the bone. Similar to changing a tire, the steel rod is jacked up and then locked into place to support the spine securely. The surgeon is then ready to fuse the vertebrae together. After this operation, patients are required to wear a full body cast and lie in bed for three to six months until fusion is complete enough to stabilize the spine.

The Harrington procedure is very difficult to undergo, particularly for young people, and although the operation can achieve a correction of the curve of over 50%, studies have reported a loss in this correction of between 10% to 25% over time. The procedure does not correct the rotation of the spine and, therefore, does not improve an existing rib hump that was caused by the rotation. The operation does not interfere with normal pregnancies and deliveries later in life.

Certain complications may occur from this procedure:

- About 40% of Harrington patients have a condition called the flat back syndrome, because the procedure eliminates normal lordosis (the inward curving of the lower back). Flat back syndrome from the Harrington procedure does not cause any immediate pain, but in later years the discs may collapse below the fusion and cause difficulty in standing erect.

- Studies have reported that five to seven years after their surgery between 20% and one-third of patients who had the Harrington procedure experienced lower back pain. (In one study, only 3% had experienced back pain before surgery.) In such cases, however, the pain was not severe enough to interfere with normal activities and did not require additional surgery.

- In children under eleven whose skeleton is immature and who have the Harrington procedure, there is a fairly high risk for a specific curve progression called the crankshaft phenomenon. This condition occurs after the procedure when the front of the fused spine continues to grow. The spine cannot grow longer, so it twists and develops a curvature.

Cotrel-Dubousset Procedure. The Cotrel-Dubousset procedure not only corrects the curve but may also help to correct rotation, and it does not cause flat back syndrome:

With this procedure, two parallel, contoured rods are cross-linked for better stability in holding the fused vertebrae.

Improvement in correction averaged 66% in one study, with a later correction loss reported to be 5%. (Other studies have reported loss of curvature correction at less than 2%.) Over 95% of patients reported the results to be good or very good (only 86% of patients who had the Harrington procedure experienced the same levels of satisfaction). Patients often go home in five days and may be back in school in three weeks.

Complication rates are similar to the Harrington procedure, but there are some differences:

- Operation time and blood loss are greater than with Harrington procedure.
- Cotrel-Dubousset and other procedures that are designed to reverse the rotation of the spine have less risk for flat back syndrome but they have a higher risk for spinal imbalance than the Harrington procedure.
- Cotrel-Dubousset instrumentation does not eliminate the risk for disc deterioration later on, which in one follow-up study occurred in nearly a quarter of the patients. Experts hope that the advances in current scoliosis procedures will help reduce the long-term adverse effects.
Third Generation or Hybrid Instrumentation. New instrumentation procedures have refined the implants used in spinal deformity operations.

- The use of pedicle screws anchored to the lumbar spine vertebrae is now common. Used for many years in adults, this technique has now become standard for children and adolescents. Pedicle screws allow much better fixation and correction of vertebral rotation than hooks. The use of screws may also allow a surgeon to fuse less vertebrae in the lower back, which may be important in preserving motion and avoiding back pain.

- Sublaminar wires (passed under the strong laminar bone covering the spinal cord) are very effective in translation (moving large curves to the midline) and are frequently used with the Unit Rod in the correction of neuromuscular scoliosis, or those curves due to cerebral palsy, muscular dystrophy or spinal cord injury.

- Pedicle screws in the thoracic spine are now used in a few centers (including A. I. duPont) for correction and instrumentation of large scoliotic or kyphotic deformities because of their strength, versatility and ability to derotate the spine. Some studies have shown better initial correction (75-80%) and limited loss of correction over time. The use of screws may avoid an anterior procedure (see below) to release the spine and/or a thoracoplasty to correct a rib cage deformity, because they are so effective at correction of scoliosis and kyphosis.

- The use of titanium implants is gaining favor due to its compatibility with human bone, strength, and ability to use MRI to scan patients after surgery, if needed.

Anterior Instrumentation. If an anterior approach is used for the spinal surgery (see below), then screws into the front of the vertebra are placed, and connected to a corrective rod.
Approaching the Patient through the Back (Posterior) or Chest (Anterior)

Posterior versus Anterior. Generally, surgeons have used a posterior approach for scoliosis; that is, they reach the area by opening the back of the patient and working on the back of the spinal column. Another alternative is the anterior approach, meaning that the surgeon performs the operation by opening the chest wall (thoracotomy) or making small incisions for a camera between the ribs (thoracoscopy) rather than entering through the back.

Posterior (Approach through the Back). With the posterior approach, the surgeon works directly on the back. It is generally used with instrumentation. It is the gold standard and has been used for decades.

- **Advantages of the Posterior Approach.** Surgeons are familiar with it and so fusion rates are excellent, curve correction is good, it takes less time, and has few complications. Two rods can be used and cross-linked together, providing excellent stability that rarely requires a brace after surgery.

- **Disadvantages of the Posterior Approach.** On the other hand, there is a risk for the crankshaft phenomenon (a worsening of the curve) later on in preadolescent children, because most of the growth of the spine is in the front. Newer posterior instrumentation, may prevent this occurrence, and some experts believe it may prove to be a good alternative to the anterior approach. The posterior approach also does not always correct hypokyphosis in the thoracic (upper) spine. (Hypokyphosis is the loss of a normal outward curvature.) The procedure is not always effective for curves in the thoracolumbar region (the region where the upper and lower spine meet) or the lower back. The blood loss is greater when the surgery is done posteriorly.

Anterior (Approach through the Chest or Flank). With the anterior approach, the surgeon makes an incision in the chest, deflates the lung, and removes a rib in order to reach the spine. (This rib is later used for bone grafting.)

- **Advantages of the Anterior Approach.** The frontal approach allows the surgeon to save fusing lower vertebrae, and the patient may have a lower risk for back pain later on. Studies show better correction (of the main curve AND compensatory curves) and function with the anterior approach than with posterior approaches alone. This may be due to the fact that the large back muscles used for posture and common activities are not scarred. Anterior surgery also allows for correction of hypokyphosis in the thoracic spine. Transfusion rates are also much lower with the anterior approach, since less blood is lost during anterior surgery.

- **Disadvantages of the Anterior Approach.** On the negative side, the anterior approach to date has a higher incidence of lung problems, pneumonia and obstruction in the gastrointestinal tract. In addition, a 1999 study reported that over time, loss of correction of more than 10% occurred in 23% of anterior patients compared to 12% of posterior patients. Implant breakage was also high: 31% in the anterior group compared to 1% in the posterior group. This study involved an implant that has been substantially modified and improved, but nonetheless, hardware failure rates are higher with the anterior than posterior approach, because only one rod is frequently used in the thoracic spine. There is also a higher risk that pseudoarthrosis may develop, a condition in which a false joint develops at the fusion site and the fusion does not heal; usually revision surgery is required.

The Combined Anterior-Posterior Approach. The combination approach uses an anterior approach first, which allows better correction of the problem. The fusion part of the operation is done with the posterior approach. This is a very long and complex procedure. It may be used in young patients to prevent crankshaft phenomenon. It may also be used to release or loosen large, rigid curves and for specific severe curves in the thoracic spine.

Endoscopy or Thoracoscopy

A promising procedure at A.I. duPont and other scoliosis centers employs endoscopic techniques. Endoscopy uses a few small incisions and so is far less invasive than the standard so-called open approaches that require wide, long incisions. In endoscopy or thoracoscopy, the surgeon makes small incisions and inserts tubes that contain tiny instruments and cameras by which to view the procedure.

In some cases, the procedure is done in two stages.

- It is employed first with an anterior approach to remove disc material and loosen the spine.

- In the second stage, a posterior approach is made for fusion and instrumentation to correct the curve.
In other cases, when the curve pattern allows, the fusion and instrumentation are done all through one thoracoscopic approach, with screws inserted into the vertebrae connected to a solid rod.

Recovery after surgery is rapid; most patients are out of bed two days after surgery, since they did not undergo a thoracotomy (opening the chest and removing a rib). Our center averages corrections of 75%, a much more cosmetically appealing result (fewer and smaller scars), and an easier recovery than with the more invasive approaches. For more information about the procedure, go to http://abcnews.go.com/sections/GMA/50states/GMA021223Scoliosis_surgery.html

The endoscopic procedure is complicated, however, and few surgeons can perform it yet. It is generally used only for curves in the upper back. Surgeons are now able to reach areas just below the diaphragm, but no lower than the first lumbar vertebra (L1). It is still not useful for adults. Long-term studies are required to know if other long-term effects are comparable to standard procedures, and whether the procedure’s cost and technical complexity is justified.

Complications of All Procedures

The complication rate is 1-3% with any of these procedures, including the standard posterior fusion and instrumentation method and the newer thoracoscopic procedures. Some of the more common ones are discussed below. A number of complications are specific to the particular procedures; these are covered in the individual sections.

Bleeding. Standard procedures increase the risk for major blood loss during the procedure. Our patients are encouraged to donate blood before the operation for use in possible transfusions. In one study, erythropoietin (rhEPO) was given to patients before the procedure. RhEPO is a hormone that acts in the bone marrow to increase the production of red blood cells. Patients who were given this hormone, particularly those with idiopathic scoliosis, needed fewer transfusions and spent less time in the hospital than those who did not receive rhEPO. Newer endoscopic techniques are reducing the need for transfusions.

Postoperative Pain. There is always some pain after these operations, which requires intravenous administration of pain relievers, such as morphine, right after the operation. (The newer endoscopic procedures may require only a short course of pain relievers.) Of some concern is a 1998 study suggesting that the use of nonsteroidal anti-inflammatory drugs (NSAIDs: aspirin, ibuprofen, naproxen) for pain relief right after fusion may increase the risk for fusion failure. Until more research is conducted, these common painkillers should not be routinely used right after surgery. Our typical protocol is administration of morphine intravenously by a patient-controlled analgesia (PCA) pump for two days, then a switch to milder, oral narcotics until discharge from the hospital and two weeks afterward, finally tapering to Tylenol as needed.

Infection. Infection is always a risk with any operation, and with pediatric spinal surgery, this risk is 1-2% in high volume centers. One study reported changes in the immune system for about three weeks after surgery, which indicates a greater risk for infection; the researchers recommended being very vigilant for signs of infection. The presence of metal implants increases the risk of infection, as does multiple surgeries, or other medical problems. Signs of infection after surgery are fever >105°F, drainage from the incision, or an increase in pain.
Nerve Damage. Neurologic injury can occur in 0.6% of patients. The risk is highest in adults. Neurologic damage can cause motor weakness and, in very rare cases, complete and irreversible paralysis. This very serious complication is prevented by using monitoring techniques during the operation. Some surgeons use a so-called wake-up test, in which the patient is brought out of anesthesia in the middle of the operations and asked to wiggle her toes. We employ motor and sensory evoked potentials, more sophisticated methods that measure the electrical activity of the spinal cord; if the monitor indicates a fall in electrical response and possible injury, the surgeon adjusts his techniques to avoid further damage to the spinal cord.

Pseudarthrosis. If the fusion fails to heal, pseudarthrosis may develop, a condition in which a false joint develops at the site. This will sometimes cause the metal implants to fatigue and break, usually the first sign that a fusion has failed to heal. Pain commonly develops with a pseudarthrosis, and revision surgery may be the only subsequent option. Smokers, and those patients who have fusions without instrumentation are most at risk for pseudarthrosis.

Disc Degeneration and Low Back Pain. Loss of trunk mobility, balance, and muscle strength from surgical treatments can also cause lower back pain and chronic problems later. Patients who are surgically treated with fusion techniques lose flexibility and the back muscles may be weakened if they were injured during surgery. Fusion in the lumbar area produces great stress on the lower back and eventually can cause disc degeneration, which can result in leg and back pain. In one study, indications of such changes occurred in between a quarter and third of patients three years after their operations, although a long-term study found that pain and disc deterioration were less than expected after 20 years. Most patients function very well for many years after surgery. We believe that our current techniques of maintaining the balance and alignment of the spine in both dimensions (coronal and sagittal) and trying to fuse as few vertebrae as possible may protect against disc degeneration.

Other Complications. Other problems that can occur include the dislodging of hooks or fracture of a fused vertebra. Children with scoliosis due to neuromuscular problems, such as spinal bifida, cerebral palsy or muscular dystrophy, may be at high risk for serious postoperative complications that involve the lungs, gastrointestinal system and circulation, which may need to be managed in an intensive care unit.

Postoperative Therapy

Breathing and coughing exercises to rid the lungs of congestion must be performed shortly after the procedure and continued through the recovery process. The patient is usually able to sit up the day after the operation, and most patients can move on their own within a week. A brace may be necessary, depending on the procedure. Patients are concerned that surgery will stiffen their backs, but most cases of scoliosis affect the upper back, which has only limited movement, so that patients do not experience much difference. It may take a year or more for muscle strength to return.

Revision, or Salvage, Surgery

Patients may need corrective surgery, called revision or salvage surgery, usually for one of four different reasons: failure of the previous procedure, curvature progression around the fusion site, disk degeneration and poor posture alignment.

Treatment of Adult-Onset Scoliosis or Uncorrected Severe Scoliosis

Surgery for adult scoliosis often involves fusion in lumbar and sacral areas, which can cause a number of complications. Some experts believe that the risks of operations in this area outweigh any benefits and should not be performed; others argue that without an operation, the back will become unstable and painful. In one study, adults with an average age of 62.8 years underwent posterior instrumentation and fusion surgery for scoliosis. After about five years, 96.6% of the patients reported good to satisfactory results. Correcting and maintaining normal lordosis (the natural curve at the bottom of the spine) appeared to be even more important in the success of the operation than simply correcting the curvature. Patients in whom scoliosis has not been treated and becomes severe are at risk for lung and heart failure. Once this has occurred, most experts do not believe that surgery will help lung capacity and, in fact, surgery can cause the condition to worsen, at least temporarily.
Where Else Can Help be Obtained for Scoliosis?

American Academy of Orthopaedic Surgeons
6300 N. River Road
Rosemont, IL 60018-4262
T: 847-823-7186 or 800-346-AAOS
www.aaos.org
Patient Education Brochure - Scoliosis

National Scoliosis Foundation
T: 1-800-NSF-MYBACK (673-6922)
E-mail: NSF@scoliosis.org
www.scoliosis.org

Scoliosis Research Society
611 East Wells Street
Milwaukee, WI 53202-3892
T: 414-289-9107
www.srs.org

Scoliosis Treatment
This site deals primarily with the surgical treatment of scoliosis. X-ray pictures of scoliosis before and after treatment are shown.
www.scoliosisrx.com

Spine-Dr.com
An informal group of patient-oriented spine surgeons across the United States organizes and develops this web site.
www.spine-dr.com

The Scoliosis Association, Inc.
P.O. Box 811705
Boca Raton, FL 33481-1705
T: 800-800-0669 or 561-994-4435
F: 561-994-2455
E-mail: normlipin@aol.com
www.Scoliosis- Assoc.org